MOULD DESIGN AND MECHANICAL ANALYSIS OF THE CASTED MATERIAL

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FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled “*Mould design and mechanical analysis of the casted material*” is written by *Mohd Azuan Bin Abu Shah*. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

MR. JASRI BIN MOHAMAD

Examiner Signature

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature :

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Date : 06 DECEMBER 2010

STUDENT'S DECLARATION

I declare that this report titled "*Mould design and mechanical analysis of the casted material*" is my result of my own research except as stated in the references. This thesis/report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : MOHD AZUAN BIN ABU SHAH

Id. Number : ME08015

Date : 06 DECEMBER 2010

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ABSTRACT

This report is an outcome of the work carried out in doing and completing final year project, mould design and mechanical analysis of the casted material. Objectives of this project is to design and fabricate the mould for tensile test specimen, following ASTM E8 standard and to study the mechanical properties of the casted materials and its comparison with effect of the cooling rate between water, oil and air. Materials that have been used for mould is mild steel and for casted material is aluminum alloy. Overall, this project was run based on four main steps; design using Solid Work, running a simulation on Master CAM, fabricates using CNC Milling Machine, and finally casting process. Each sample was then tested by Rockwell hardness in order to study the effect of the cooling media to the hardness of casted material for all three cooling media, water, oil and air. It project was done by testing at the outer surface and inner surface of the casted aluminum alloys. The higher value for outer surface hardness test is 49.10 HRB and the higher value for inner surface hardness test is 37.72 HRB. The result shows the hardness of casted material immersed in water has higher value compared to oil and air. Water has proved to be the best mediums for cooling rate compare to oil and air medium. The hardness of aluminium increases with the increasing of cooling rate. Cooling rate decreases with distance from the quenched end, and the hardness also decreases.

ABSTRAK

Laporan ini ialah satu hasil kerja dijalankan dalam melakukan dan menyiapkan projek tahun terakhir, membentuk reka bentuk dan analisis mekanik bahan dicor. Tujuan dari projek ini adalah untuk merancang dan membuat cetakan untuk spesimen uji tarik, mengikuti ketetapan ASTM E8 dan untuk mempelajari sifat mekanik bahan dicor dan perbandingannya dengan kesan kadar penyejukan antara air, minyak dan udara. Bahan-bahan yang telah digunakan untuk cetakan adalah keluli lembut dan bahan dicor adalah paduan aluminium. Secara keseluruhan, projek ini dijalankan berdasarkan empat langkah utama; mereka bentuk menggunakan *Solid Work*, menjalankan simulasi menggunakan perisian CAM, mereka menggunakan mesin kisar CNC, dan akhir sekali adalah proses tuangan. Setiap sampel yang diuji oleh kekerasan Rockwell untuk mempelajari pengaruh media pendinginan untuk bahan dicor untuk ketiga-tiga media pendinginan iaitu melalui air, minyak dan udara. Projek ini telah dijalankan dengan melakukan pengujian pada permukaan luar dan permukaan dalam dari gabungan aluminium dicor. Nilai yang tertinggi untuk ujian kekerasan pada permukaan luar ialah 49.10 HRB dan nilai tertinggi untuk ujian kekerasan permukaan dalam ialah 37.72 HRB Keputusan kajian menunjukkan kekerasan bahan dicor direndam dalam air mempunyai nilai lebih tinggi berbanding dengan minyak dan udara. Air telah terbukti menjadi media terbaik untuk membandingkan kadar penyejukan diantara minyak dan medium udara. Kekerasan aluminium meningkat dengan meningkatnya kadar penyejukan. Kadar penyejukan berkurangan dengan jarak dari menghilangkan akhir, dan kekerasan juga berkurangan.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

mm	Millimeter
MPa	Megapascal
GPa	Gigapascal
%	Percent
HB	Brinell Hardness Number
HR	Rockwell Hardness Number
D	Diameter of Steel Ball
sec	Second
lbf	Pound of Force
σ	Stress
F_0	Minor Load
F_1	Major Load
F	Total Load
ρ	Density
A	Area
V	Volume
e	Depth of Penetration
l	Instantaneous Length
l_o	Original Length
E	Modulus of Elasticity

LIST OF ABBREVIATIONS

AA	Aluminum Association
AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Material
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CNC	Computer Numerical Control
FKM	Fakulti Kejuruteraan Mekanikal
HPCC	High Precision Contour Control
HRB	Hardness Rockwell Brinell
ISO	International Organization for Standardization
NC	Numerical Control
RISC	Reduced Instruction Set Computer
RPM	Rotation Per Minutes
UMP	Universiti Malaysia Pahang
V/A	Volume per Surface Area
2D	Two Dimension
3D	Three Dimension

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Casting is a manufacturing process where a solid is melted, heated to proper temperature (sometimes treated to modify its chemical composition), and is then poured into a cavity or mold, which contains it in the proper shape during solidification. Thus, in a single step, simple or complex shapes can be made from any metal that can be melted. The resulting product can have virtually any configuration the designer desires. Since metal casting involves working with metal in its molten form, the process can be dangerous if undertaken by the reckless or ill informed. The melting points of several metals are well above 1,000 degrees Fahrenheit, or 530 degrees Celsius. It is vital that anyone wanting to work with metal casting take all the proper precautions.

Casting has marked advantages in the production of complex shapes, parts having hollow sections or internal cavities, parts that contain irregular curved surfaces (except those made from thin sheet metal), very large parts and parts made from metals that are difficult to machine. Because of these obvious advantages, casting is one of the most important of the manufacturing processes.

Today, it is nearly impossible to design anything that cannot be cast by one or more of the available casting processes. Metal casting requires specialized equipment, knowledge, and some creativity. While metal casting is used on an Industrial level as the process cuts cost and proves to be highly efficient. However, as in all manufacturing techniques, the best results and economy are achieved if the designer understands the various options and tailors the design to use the most appropriate process in the most efficient manner. The various processes differ primarily in the mold material (whether sand, metal, or other material) and the pouring method (gravity, vacuum, low pressure, or high pressure). All of the processes share the requirement that the materials solidify in a manner that would maximize the properties, while simultaneously preventing potential defects, such as shrinkage voids, gas porosity, and trapped inclusions.

Based on that case, the project title was proposed is mould design and mechanical analysis of the casted material. This project involves the designing process, simulation process, fabrication process and analysis process. The project start from design the mould using computer aided design (CAD) software and then simulation using master cam (CAM) software. After that the project continues with fabrication the mould using CNC Milling Machine and next process is mould casting. The finally is mechanical analysis process for the product cast. At the end of the project, all the process method will combine to study and investigate the defects of gases, gating system and mold design and material selection in metal casting and other defects.

1.2 PROBLEM STATEMENT

As in all metal casting process, certain guidelines and design principles pertaining to casting have been developed over many years. Although these principles have been established primarily through experience, analytical methods, process simulation and modeling, and computer aided design and manufacturing techniques have all come into wide use as well, thus improving productivity and the quality of castings and resulting in significant cost savings.

However, products that are produced with casting process still have defective. In most cases a given mold design will produce mostly well with some defective. It is very difficult for a mold to produce no defective parts and some defective ones. There are many defective that are found in products primarily due to gassing, pouring method, size of risers and etc. However, this kind of causes is difficult to control since process of casting is a hands-on process by human itself and not machine where it involves pouring the melted material into mould. Thus, in this project, the system for casting in terms of gating system and risers will be designed and calculated purposely to reduce the defects of part to be casted. Furthermore, the study about the mechanical properties of the casted material has not been an interested topic among researchers. Hence, investigation to the changes of aluminum mechanical properties after the casting process will be examined in this project.

1.3 PROJECT OBJECTIVES

Basically, the specific objectives of this project are:

1. To design and fabricate the mould for tensile test specimen, ASTM E8.
2. To study the mechanical properties of the casted materials by quench the aluminum alloys to different cooling media which are water, oil and air.

1.4 PROJECT SCOPES

This project will be carried out by using specific software and machine in the process of designing and fabricating the mould of casting. The dimension of the casted dog-bone shape for the tensile test specimen will be according to ASTM standard E8 as shown in Figure 2.1 in chapter 2. The material and hardware to be used to carry out this project is listed as follows:

1. Types of material to be used in this project are restricted to only aluminum for the casted material and mild steel as the mould.
2. The design of mould is according to dog-bone shape standard ASTM E8 and it will be done by using Solid Work as the design software.
3. Master CAM software used to simulate the machining process of mould fabrication.
4. Fabrication process of the mould has done by using CNC milling machine.

CHAPTER 2

LITERATURE REVIEW

2.1 TENSILE TESTING SPECIMEN (ASTM E8)

Consider the typical tensile test specimen is shown as Figure 2.1. It has enlarged ends or shoulders for gripping. The important part of the specimen is the gage section. The cross sectional area of the gage section is reduced relative to that of the remainder of the specimen so that deformation and failure will be localized in this region. The gage length is the region over which measurements are made and is centered within the reduced section. The distances between the ends of the gage section and the shoulders should be great enough so that the larger ends do not constrain deformation within the gage section, and the gage length should be great relative to its diameter (Davis Joseph, 2004).

There are various ways of gripping the specimen, some of which are illustrated in Figure 2.3. The end may be screwed into a threaded grip, or it may be pinned; butt ends may be used, or the grip section may be held between wedges. The most important concern in the selection of gripping method is to ensure that the specimen can be held at the maximum load without slippage or failure in the grip section. Bending should be minimized (Davis Joseph, 2004).

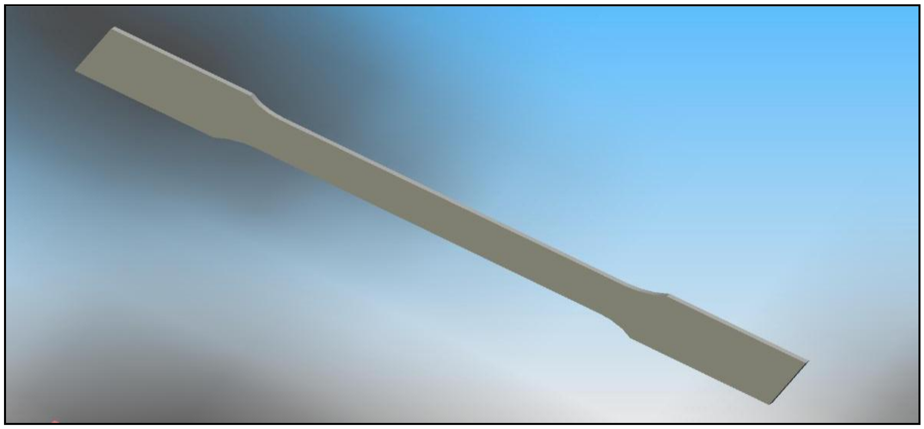

Figure 2.1: Specimen for tensile test

Source: Davis Joseph, 2004

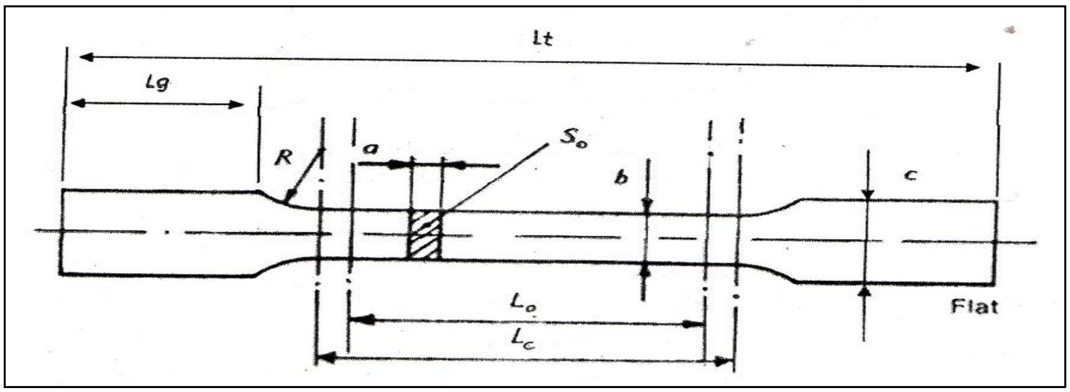

Figure 2.2: Specimen preparation according to ASTM specifications

Source: Davis Joseph, 2004

Table 2.1: Detail Dimension for Tensile Test Specimen

No.	Item	Dimension
1	Lt, Total Length	Min 8" (20.32cm)
2	Lg, Grip Length	Min 2" (5.08cm)
3	Lo, Gauge Length	2.000" ± 0.0005" (5.08 ± 0.0127cm)
4	Lc, Parallel or Reduce Section	Min 2.25" (5.715cm)
5	R, Radius	Min 0.5"
6	a, Thickness	0.2" (0.4cm)
7	b, Gauge width	0.500" ± 0.01" (1.27 ± 0.0254cm)
8	c, Grip width	Approx. 0.75" (1.905cm)

Source: Davis Joseph, 2004